A Lightweight Framework for Reproducible Parameter Sweeping in Information Retrieval

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Motivation

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Problems with experiments

What happens if the original researcher leaves?

How can we preserve the experiment in a repeatable way?

Experimentation Framework

Requirements

Must get out of the way

Must facilitate repeatable experiments

Must preserve experiment results

Our Goal

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Conduct our Information Retrieval experiments

1. with a **lightweight declarative** set up

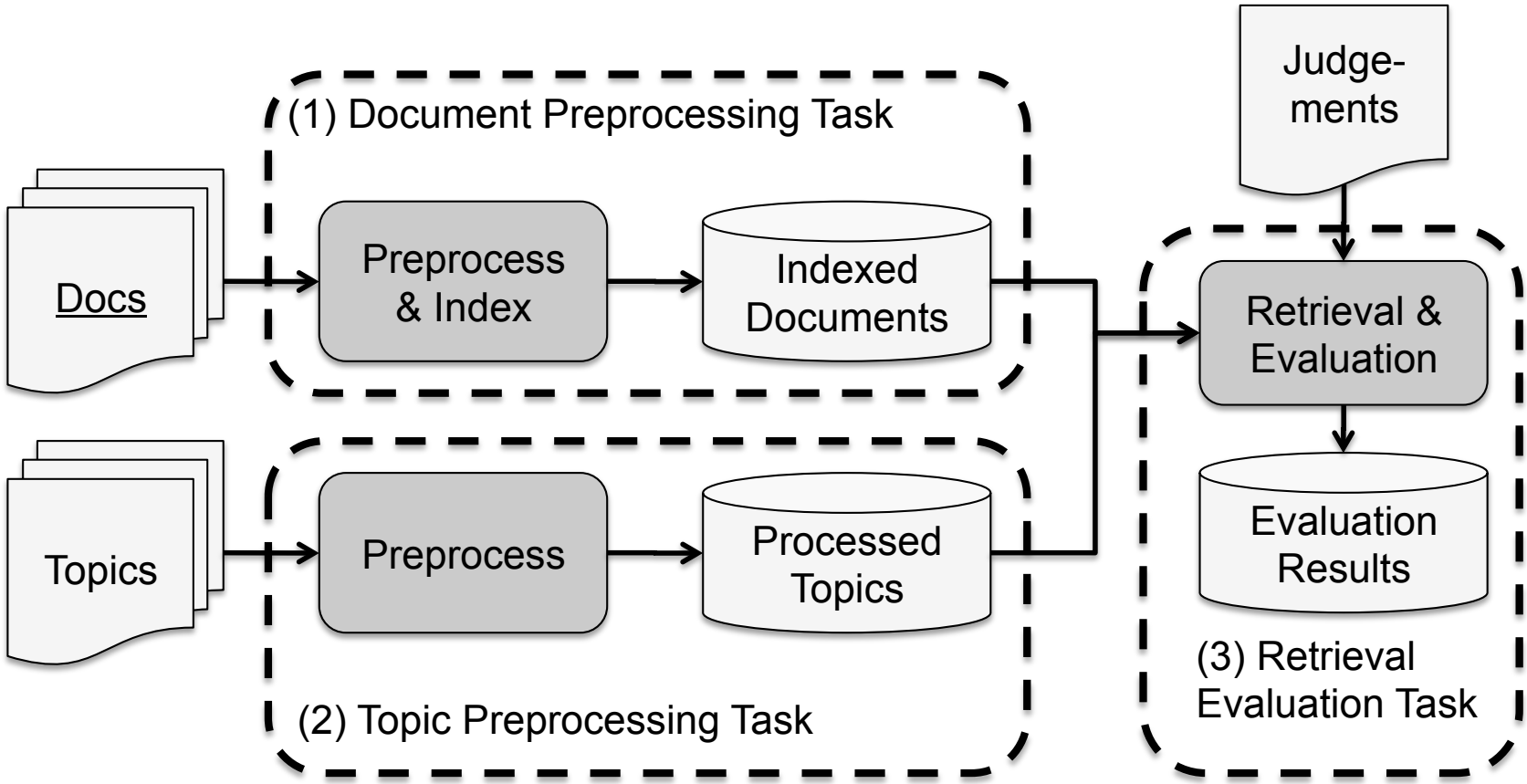
2. with **parameter sweeping**

3. in a **reproducible** manner

Generic core framework for arbitrary experiments

Extensions for application domains (e.g. IR)

A typical IR experiment



Parameters

- Data set
- Stop word list
- IR model
- Fields
- Pruning
- …

DKPro Lab Framework

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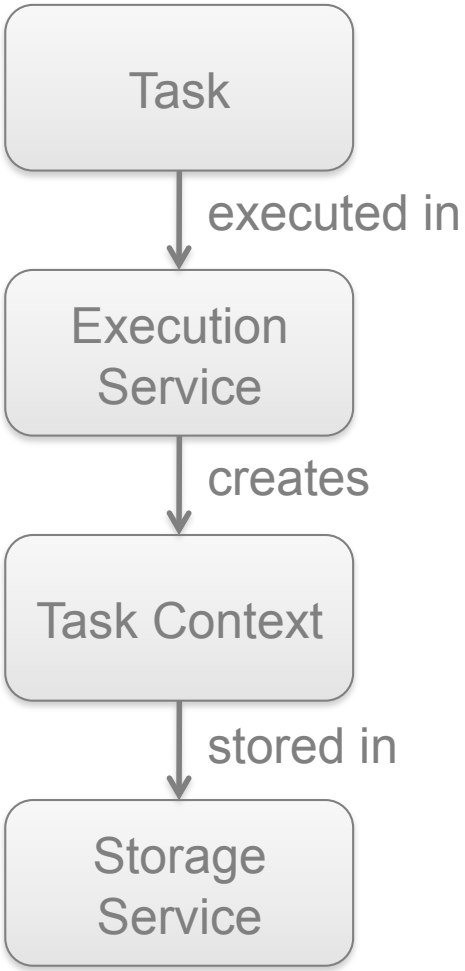
- High-level experimentation framework
- Modular architecture
- Lightweight implementation

- Declarative all-in-one style for reproducible experiments
- Model tasks and data dependencies
- Parameter sweeping

- Preserve results
- Generate reports

- Java or Groovy



Task

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- Configurable unit of work
- Can be executed multiple times with different configurations
- Adapts between the Lab and the low-level experiment code

```
class DocumentIndexingTask extends ExecutableTaskBase {
        @Discriminator File documentsPath;
        @Discriminator String language;
        @Discriminator DiscriminableClosure termSelector;

        public void execute(TaskContext aContext) throws Exception {
                // read files from documents
                // apply language-specific pre-processing
                // select terms to index from document
                // write document terms to the index
        }
}
```

Parameters

Experiment Logic

Parameter

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- Supported are all types with *v1.toString() == v2.toString ⇔ v1.equals(v2)*
  - String, Integer, Boolean, …, File, URL, …
- Collection types need to have a stable element order
  - Good: ArrayList Bad: HashSet
- Closures can be parameters
  - Inject pieces of code for maximum flexibility


```
Dimension dimInnerProduct = new ClosureDimension("innerProduct", [
    "Cosine":     { vec1, vec2 -> cosine(vec1, vec2) },
    "Lesk":       { vec1, vec2 -> overlap(vec1, vec2) }, ]);
```

```
def score = innerProduct(queryVector, documentVector)
```

Parameter Space

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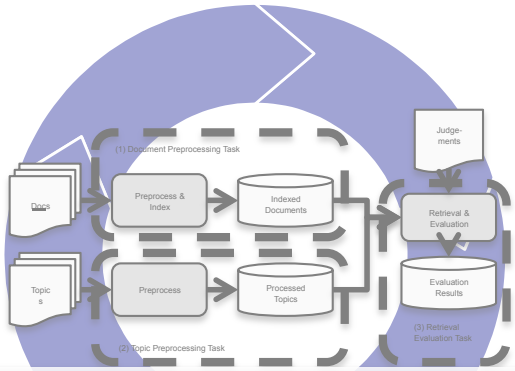
- Space of all possible parameter combinations

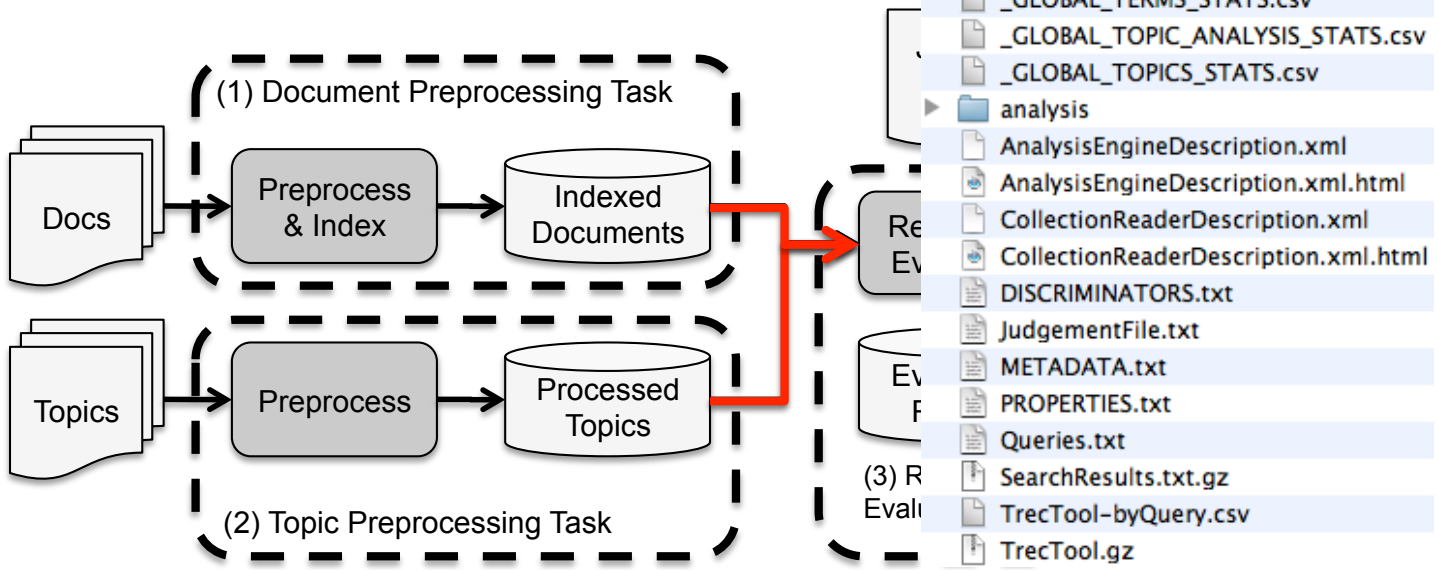



```
ParameterSpace pSpace = [
        dimDataSet, dimIrModel, dimTermSelector ];

def dimDataSet = Dimension.createBundle(
        "dataSet", dataSetEn, dataSetDe);

def dataSetEn = [
        __bundleId:         'dataSetEn',
        language:           'en',
        documentsPath:      'src/test/resources/en/documents' as File,
        topicsPath:         'src/test/resources/en/topics' as File,
        judgementFile:      'src/test/resources/en/judgements/judgements.qrels' as File];

def dataSetDe = [
        __bundleId:         'dataSetDe',
        language:           'de',
        documentsPath:      'src/test/resources/de/documents' as File,
        topicsPath:         'src/test/resources/de/topics' as File,
        judgementFile:      'src/test/resources/de/judgements/judgements.qrels' as File];
```

@Discriminator String **language**;
@Discriminator File **documentsPath**;

Data dependencies

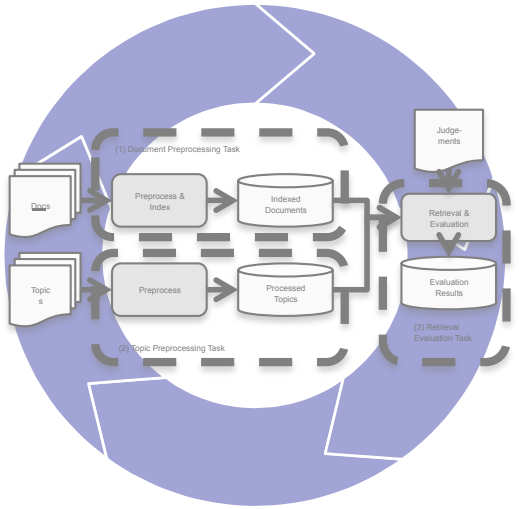
- Lab provides new context for each task execution (think directory)
- Data read/stored by keys (think files and directories)
- Data can be imported from other tasks via these key

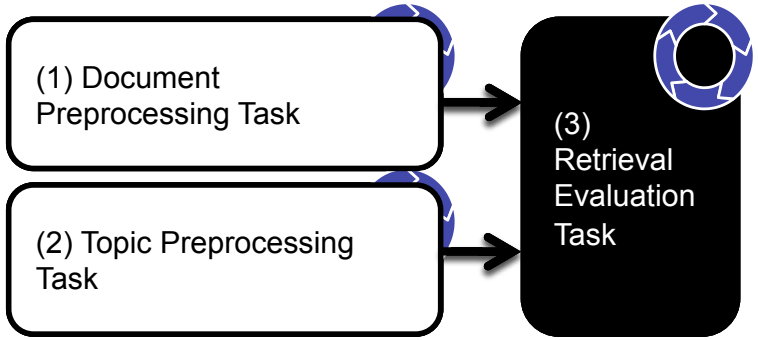



```
evaluationTask
  addImportLatest(KEY_DOC_INDEX,    KEY_INDEX,        docIndexingTask);
  addImportLatest(KEY_TOPIC_XMI,    KEY_XMI,          topicPreprocessingTask);
  addImport(JUDGEMENT_FILE_KEY, judgementFile);
```

Batch Task

- Parameter sweep over a set of tasks
- Data dependencies control task execution order
- Tasks executed only when affected by a parameter change





Parameters

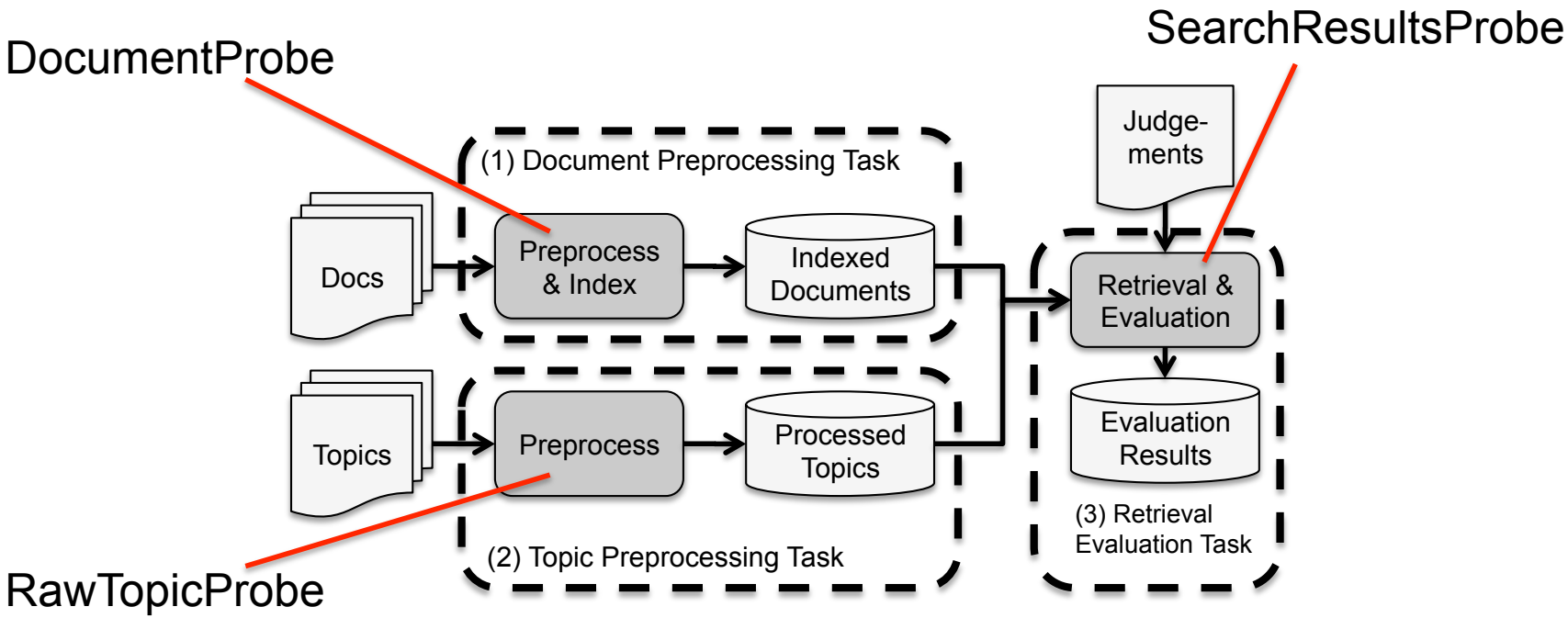
Data Set

IR Model

```
BatchTask batchTask = [
        parameterSpace:   [ dimDataSet, dimIrModel, dimTermSelector ],
        tasks:            [ docIndexingTask, topicPreprocessingTask, evaluationTask ],
        reports:          [ TrecBatchReport, IrBatchReport, PairedTTestReport ] ];
```

Probes

- Probes record information about a task
- Design pattern, not an API
- Built directly into the tasks



UIMA Task with Probes
DocumentIndexingTask

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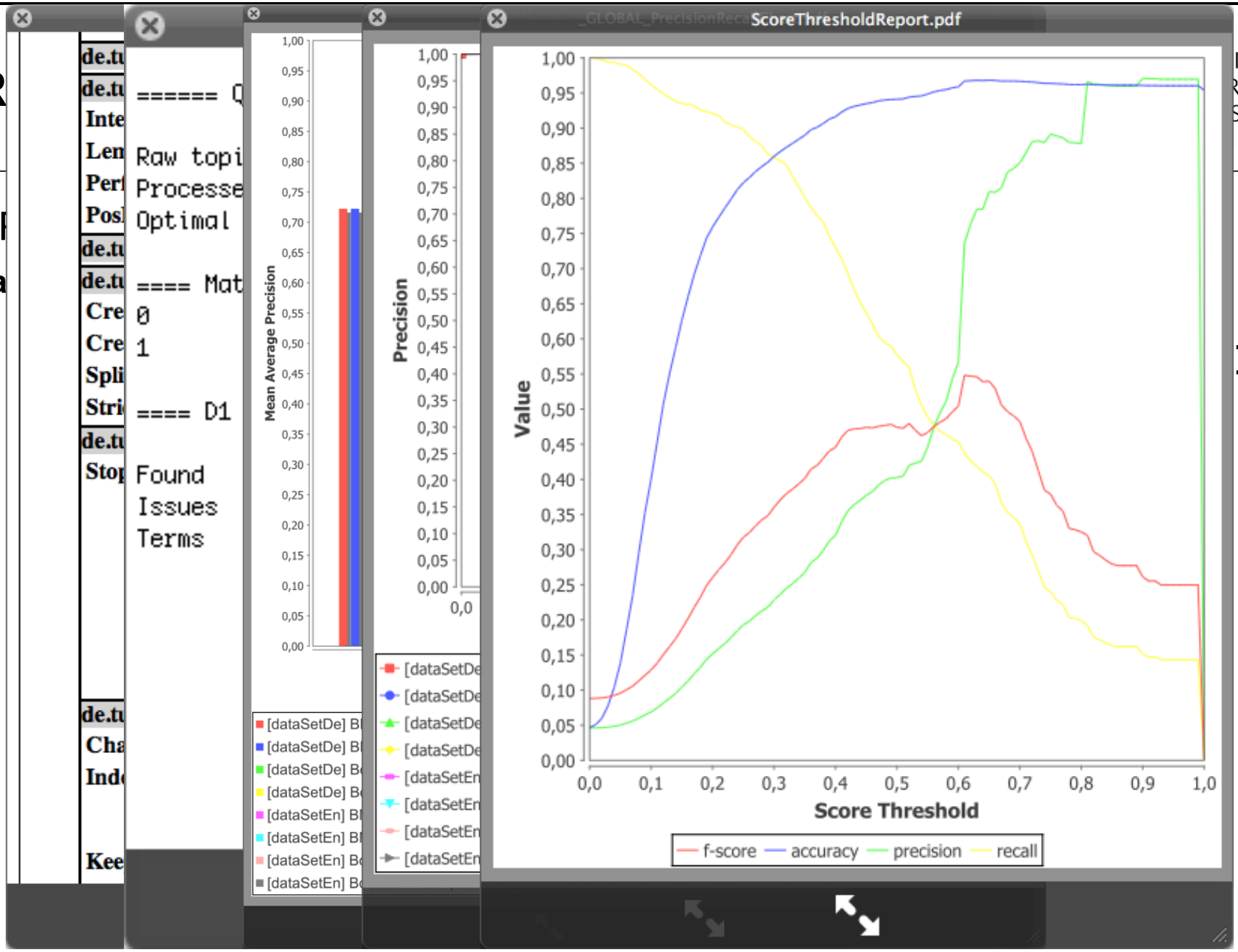
```
AnalysisEngineDescription getAnalysisEngineDescription(TaskContext ctx) {
    File output = ctx.getStorageLocation(KEY_XMI, READWRITE);
    File outLucene = ctx.getStorageLocation(KEY_INDEX_LUCENE, READWRITE);

    return createEngine(
        createEngine(BreakIteratorSegmenter),
        createEngine(TreeTaggerPosLemmaTT4J),
        createEngine(StopWordRemover, ...),
        createEngine(SnowballStemmer, ...),
        createEngine(IndexTermAnnotator, ...),

        createEngine(LuceneIndexWriter, PARAM_INDEX_PATH, outLucene.path),

        createEngine(DocumentProbe),
        createEngine(ShallowFeaturesProbe))
}
```

Pre-processing

Indexing

Probes

Courtesey of DKPro Core & DKPro IR


ScoreThresholdReport.pdf
Mean Average Precision
Precision
Value
Score Threshold
f-score
accuracy
precision
recall

DKPro Lab IR Extension Package

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Data models

- Judgment set
- Document set
- Topic set
- Evaluation result set

Probes

- Document text
- Raw and processed topics
- Search results
- Type/Token ratio

Reports

- Result type report
  - True/false positive/negative stats
- TRECeval report
  - Precision, recall, etc.
- Accuracy report
  - Accuracy by score threshold
- Correlation report
  - Pearson/Spearman correlation
- Significance report
  - Paired-T test

Anatomy of a Lab Experiment

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- Basic setup
  - 1 file describing the experimental setup and parameters
  - 1 file per task (recommended)
- Optional setup (shared between experiments)
  - 1 file per report
  - 1 file per data model
- DKPro Lab provides convenience classes for
  - Scalable PDF charts (based on JFreeChart)
  - Flexible data tables (render as Excel, CSV, TWiki)

Summary and Outlook

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- Summary
  - DKPro Lab is a generic parameter sweep experiment framework
  - Lightweight and very extensible
  - Facilitates repeatable experiments
  - Demonstrated application for Information Retrieval
- Outlook
  - Deploy and run experiments on a compute cluster, e.g. using Apache Hadoop
  - Add extensions for other areas, e.g. Machine Learning
- Open Source
  - Apache License
  - Hosted on Google Code – http://code.google.com/p/dkpro-lab/
  - Currently the core framework and an ML example

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Thank you!

Questions?

Thanks to all my colleagues at UKP!

Used templates from www.presentationmagazine.com